PATENT SPECIFICATION

724,875

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COMPLETE SPECIFICATION

Improvements in and relating to Dynamo-Electric Machines

We, GENERAL ELECTRIC COMPANY, a Corporation of the State of New York, United States of America, having its office at Schenectady 5, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to improvements in dynamo-electric machines and has particular significance in connection with ventilating arrangements for core members (be they for the rotor or stator) of turbine generators.

Conventionally, generators adapted to be driven by steam turbines to supply large amounts of power each having a stationary outer core member having slots containing an armature winding adapted to provide a.c. output when excitation is provided by a rotor core member having slots containing a field exciting winding energized by direct current. The longer the cores and the windings, the more difficult it is to force the requisite cooling gas toward the axial centre, and one of the principal limiting factors affecting the output of such large machines is the temperature rise of the copper conductors making up the stator and rotor windings. In the past, this temperature rise has been affected by the thickness and nature of the insulation surrounding the conductors. Unfortunately, a relatively good electrical insulator is a relatively poor thermal conductor, and if excessive current values force conductor temperature rise too high, temperature deterioration of the dielectric characteristics of the insulation may be so rapid as to cause premature electrical failures. Many times during the past forty years, attempts have been made to place a cooling medium inside the insulating jacket which surrounds the metallic conductor so that a much lower temperature rise of insulation can be realized because the heat will not have to pass through the insulation. Thus, it has been suggested that holes be provided longitudinally through the centre of each conductor, but it has been found that this arrangement makes it very difficult to get the cooling gas in and out of the bores so provided in the conductors. Likewise, it has previously been suggested that the sides of the conductors be hollowed out, adjacent the insulation, but all such prior art arrangements with which we are familiar have caused difficulties associated with great length of ventilating medium travel from one end of the core to the other.

It is an object of the present invention to provide simple and inexpensive means for overcoming the above-mentioned difficulties.

A further object of the present invention is to provide improved ventilation and heat dissipation means for use in a dynamoelectric machine core member to increase the rating of a machine of given dimensions or, alternatively, decrease the required dimensions for a machine of the same rating.

A still further object of the present invention is to provide an arrangement for within-the-insulation-ventilation of electrical conductors occupying slots of a dynamoelectric machine core member, which arrangement will permit a more uniform and better distribution of cooling gas through the core and adjacent the conductor material, thus making it possible to construct a machine of smaller size for a comparable rating than is possible when using other ventilation arrangements heretofore proposed.

Briefly stated, in accordance with the invention, the sides of the conductors in the rotor or stator are cut out to provide axial grooves (leaving axial tongues) between the conductor bar material and the slot insulation, means are provided for introducing cooling gas to the axial grooves from favourable high pressure gas areas, such as at the ends of the grooves, and radial passages are arranged to extend through the adjacent core teeth between the axial grooves and the core face bordering the air gap for discharging the gas from the axial grooves.

The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a sectional view in perspective of a portion of a turbine generator slotted rotor provided with the conductor elements of a rotor winding and constructed in accordance with the present invention;

Fig. 2 is a perspective view of one of the conductor bars shown in Fig. 1;

Fig. 3 is a side elevational view, partly broken away, of a turbine generator provided with a rotor having a construction such as that illustrated in Fig. 1 along zones at the opposite axial ends thereof and having a different construction in a middle zone;

Fig. 4 is a diagrammatic representation of ventilating gas flow through the centre zone of the rotor and through the right-hand end zone thereof;

Fig. 5 is a cutaway view in perspective of the construction of a portion of the slotted rotor core and conductors therein in the centre axial zone as indicated in Figs. 3 and 4.

Referring now to Fig. 1, we have shown the invention in connection with a portion of a large turbine generator rotor comprising an annular magnetic core 11 which may be a large forging well over 10 ft. in length and 3 ft. in diameter and provided with axially extending winding slots containing a rotor winding made up of superposed individual conductor bars 12 arranged in the slots and adapted to be energized in a conventional manner (such as through slip rings, not shown).

Conductor bars 12 are so shaped as to have axial grooves or openings 13 in their sides through which cooling gas may flow, as indicated by arrows 14, in contact with the conductor proper and within outer or slot insulation 15. The cooling gas, which may be assumed to be hydrogen, is introduced into the grooves 13 at each end of the rotor, as hereinafter explained in connection with Fig. 3, and travels axially along these conductor openings until it meets one or more exits. The exits comprise a suitable arrangement of shallow and deep radial holes 16, 17 (respectively) drilled in the tooth portions between the winding slots and at axially spaced intervals, for example, every 12 in., with the holes being staggered between teeth as indicated in Fig. 1. The grooves 13 in the conductor bars 12 leave top and bottom tongues 19 which are cut away to provide rectangular exit areas adjacent these radial holes, and, although other suitable arrangements can readily be envisioned, as seen in Fig. 2, each bar tongue is alternately cut away for a small extent 20 and a greater extent 21 in a repetitive pattern along the axial length of the conductor. One suitable arrangement of shallow holes 16 and deep holes 17 is pictured in Figs. 1 and 4 and comprises alternately a hole 16 of lesser length and a hole 17 of greater length, and the conductor bars are stacked so that at each shorter through-the-tooth radial exit 16 there is a lower group of conductors having axial short cutout portions 20 with a superimposed top group of conductors having a longer cutout portion 21. At such a point, the flow of ventilating medium is upward through the shorter cutouts 20 of the lower group of conductors and upward and downward through the longer cutouts 21 of the upper group of conductors and then tangentially through a hole 22 in the insulation and through a hole 23 in the tooth portion and communicating with the radial shallow hole outlet 16. Meanwhile, at alternate axial locations, as most clearly seen in Fig. 4, at the second exit duct from the right-hand end, the arrangement is a lower group of conductors having longer cutouts 21 and an upper group of conductors having shorter cutouts 20, and the direction, radially, of ventilating medium flow adjacent the cutout sections is reversed, that is, downward through the upper-section cutouts and upward and downward through the lower section cutouts and then through holes 22 and 23 (Fig. 1) into the bottom of the deep hole radial exit 17 in the tooth portion. We have found that a tangential hole, such as 23, can readily be cut by means of an L-shaped tool comparable to a dentist drill, and which can be inserted either in the radial hole (16, 17) or in the winding slot itself before the winding is placed therein; but we do not mean to limit the present invention to the L-shaped passages thus provided since, obviously, diagonal passages from tooth periphery to winding slot could be used instead.

Referring now to Fig. 3, which is a cutaway elevational view of a generator embodying the invention, we have shown the rotor core 11 of Fig. 1. In Fig. 3, the rotor conductor bars 12 and their grooves 13 are hidden by the insulation 15 although the rotor gas passages are indicated to some extent by the location of the holes 22 in the insulation. Since the rotor and stator cores of modern large high-speed turbine generators are usually more than 10 ft. in length, thus creating quite a problem in connection with ventilation of the core portions adjacent the axial centre of the machine, we provide a different cooling arrangement for a centre part, or zone, of the rotor core. In Fig. 3, there is indicated a right-end zone 24, a left-end zone 25, and a centre zone 26, and unlike the arrangement in end zone 24 (which is fed as described in connection with Fig. 1), and unlike end zone 25 (fed the same as 24 except opposite hand), the centre zone 26 is fed partly or, as shown, entirely from a sub-slot 27 which extends be-

neath the winding in each winding slot for the entire length of the rotor, as indicated in Figs. 1, 3, 4 and 5. Ventilating gas is introduced into the ends of this sub-slot and travels toward the centre of the rotor core as indicated by some of the arrows 14 in Fig. 3. The rotor provides a rotating field co-operating electrodynamically with a stator core portion, which in the illustrated embodiment comprises stacks 28 of laminations interspaced by radially extending ventilating passages 29. The stator core portion is provided with winding slots containing the individual elements of a stator winding 30 around and between which the ventilating medium flows while passing through the radial ducts 29 as indicated by a portion of the arrows 14. The machine is provided with axial flow fans 31 rotatable with the shaft of the machine and adapted to circulate ventilating medium through the sub-slots 27, the conductor side grooves 13, and eventually (as hereafter described) out to the rotor periphery across the so-called "air-gap," then up through the radial ducts 29 and out of the stator core and into one or more coolers 32, with the ventilating medium in the vicinity of the coolers travelling both tangentially and axially until it finally returns to the intake of one or the other of fans 31 provided at each end of the machine. Rotor end turns 12*e* are held in place at each end by a more or less conventional retaining ring 33 pressed over the assembly and onto a centering ring 34 through which axial holes are provided to allow introduction of the cooling medium (from the fan 31 discharge) into the sub-slots 27 and conductor grooves 13. The machine is provided with an outer housing 35, bearings 36, and shaft seals 37, and, as already explained, the cooling arrangement differs in axial zones 24—26 according to whether the cooling medium originates primarily from the sub-slots as it does in centre zone 26 or whether it originates from the conductor grooves 13 provided in the sides of the conductors as it does in end zones 24 and 25.

Referring now to Fig. 4, we have shown a diagrammatic illustration of a portion of the rotor core in right-hand end zone 24 (at the right in Fig. 4) and of a portion of the rotor core in centre zone 26 (at the left in Fig. 4). The arrangement in end zone 24 may also be understood from consideration of Fig. 1, and the arrangement in centre zone 26 may be understood from consideration of Fig. 5, which is a perspective and sectional view of a rotor portion in the centre zone and showing, as indicated by arrows 14, the ventilating medium travel through the sub-slot 27 entering through tangential holes 23^1 into the bottoms of extra deep radial passages 18 provided in the tooth portions intermediate the winding slots. These passages 18 are even deeper than the longest passages 17 characteristic of the end zones (and shown in Fig. 1) and are, moreover, sealed at their top ends by the threaded engagement of sealing plugs 38 which cause these longer radial slots 18 to act not as exit ducts but as entrance ducts from which the cooling gas leaves by way of additional tangential holes 23 through the tooth and communicating through a hole 22 provided in the winding slot insulation with wide conductor tongue cutouts 21 characteristic of a lower group of conductors and communicating with narrower cutouts 20 characteristic of an upper group of conductors and then the ventilating medium, as indicated by arrows 14, travels through the ducts 13 formed in the side of the conductor bars away from the centre of the machine on one side of the entrance duct 18 and toward the centre of the machine on the opposite side of the entrance duct until it finds its way to alternate shorter radial exit ducts 16 from which it discharges, in a manner similar to that described in connection with Fig. 1, into the air gap and then through the stator radial cooling ducts 29 and around and through the coolers 32 and back to the entrance of the fans at each end of the machine, as indicated in Fig. 3.

While we have illustrated and described the present invention relating to means for getting cooling fluid directly against current carrying members of a dynamoelectric machine core, only in connection with cooling circuits from the rotor core winding conductors, obviously the same or similar means could be extended to take care of direct cooling of stator winding conductors as well. It will be noted that with the arrangement disclosed, means are provided for permitting cooling gas to enter cooling passages from favourable high pressure gas areas and to leave through controlled and selected exit areas to afford efficient use of the cooling properties of the cooling gas. The shape of the ventilating grooves in the sides of the conductors can be of any suitable configuration, and these grooves connect directly with the end structure of the machine beneath the retaining rings to permit the gas to flow into these conductor openings. While the conductors are shown recessed in rectangular areas for gas passage between grooves, the areas could be circular or of another shape and serve just as well to distribute the ventilating medium adjacent the exits (or entrances) comprising the radial holes drilled in the tooth and tapped through the slot wall and insulation. The recessed areas serve an important function in allowing more than adequate creepage distance of insulation between the metal of the core 11 and the metal of the conductors 12 adjacent the openings 22 in the insulation. It is to be particularly noted that with the arrangement of the invention, there is no substantial narrowing of the flux carrying area of the tooth intermediate the winding slot because the usual axial ventilating passages in such teeth have now been elimin-

ated and because the radial ducts through the teeth will have no appreciable effect on flux carrying ability since these radial h les are axially spaced by an amount relatively great compared to their own width. Because the arrangement of the invention allows smaller machines for the same rating, it has the important advantage of resulting in a substantial saving in copper and in steel, and there is thus provided a device of the character described capable of meeting the objects hereinabove set forth.

While we have illustrated and described a particular embodiment of invention, various modifications will obviously occur to those skilled in the art.

What we claim is:—

1. A dynamo electric machine having a stator member and a co-operating rotor member with said stator, said members each having a core and windings comprising insulated conductor bars carried in slots in said core, and at least one of said members having ventilating means including the provision of cut-away sides in the conductor bars to provide longitudinally extending grooves between the conductor bar material and the slot insulation, means for introducing a coolant gas to said longitudinal grooves, and radial passages extending through the adjacent core teeth between the longitudinal grooves and the core face bordering the air gap for discharging the gas from the longitudinal grooves.

2. A dynamo electric machine as claimed in Claim 1, in which the rotor is formed with longitudinal grooves in the conductor sides and discharge passages through the core teeth.

3. A dynamo electric machine as claimed in Claim 1 or Claim 2, in which the longitudinal grooves in the conductor sides define side walls abutting against the slot insulation, which walls are cut away in the neighbourhood of the discharge passages to provide radially extending passages connecting a number of longitudinal grooves with a discharge passage.

4. A dynamo electric machine as claimed in Claim 3, having ports in the sides of the core slots providing communication between the longitudinal grooves and radial discharge passages in the core teeth, successive ports (taken in an axial direction) communicating alternately with the upper and lower parts of the slot, and the conductor groove walls being cut away to provide radial passages between the sides of the conductor and the slot sides connecting all the longitudinal grooves along one side of a slot discharge port.

5. A dynamo electric machine as claimed in Claim 4, in which each radial passage along the conductor sides is relatively large along the part (i.e. upper or lower part) of the slot with which the discharge port communicates, and is relatively smaller along the other part.

6. A dynamo electric machine as claimed in any one of Claims 2 to 5, including axial ducts extending through the core below the slots and communicating through inlet slot passages with the conductor grooves at positions spaced from the discharge ports, the walls bordering the slot grooves being cut away to provide radial passages between the conductor and slot sides in the neighbourhood of the inlet slot passages to enable inlet gas to be fed to all the conductor grooves.

7. A dynamo electric machine as claimed in Claim 5, in which cooling gas is fed to the conductor grooves along the mid section of the rotor and discharged therefrom along the two end sections.

8. A ventilating arrangement for a dynamo electric machine having annular magnetic core provided with axially extending winding slots defining teeth therebetween, and having a winding comprising superposed conductor bars arranged in said slots with slot insulation between the walls of each slot and the superposed conductor bars therein, said conductor bars having axially extending grooves defining tongues on their sides adjacent said insulation, fan means for introducing ventilating gas to the ends of the said grooves, said conductor bar tongues being cut away at spaced axial intervals to provide exit areas, and said teeth having a plurality of outlet passages each opening at one end at the periphery of said rotor and each communicating at the other end through said insulation with at least one of said exit areas for allowing said ventilating gas to leave said grooves intermediate the ends of said core.

9. A ventilating arrangement for dynamo electric machine having annular rotor core member provided with axially extending winding slots and having a winding comprising superposed conductor bars arranged in said slots with slot insulation between the walls of each slot and the bars therein, said bars having their sides provided with axially extending grooves defining ventilating passages intermediate tongues adjacent said insulation, said core member being provided with additional ventilating passages in the form of sub-slots located beneath the conductor bar occupied winding slots, said tongues being cut away at axially spaced intervals to provide areas for gas passage radially between the grooves of superposed conductor bars, fan means for introducing ventilating medium to the axial ends of said sub-slots, a plurality of radial and tangential passages through said core at axially spaced intervals between said winding slots with some of said plurality of passages communicating between the sub-slots and the areas for gas passage between grooves in an axially centre zone of said rotor core, and other of said plurality of passages communicating between the rotor outer periphery and areas for gas passage between grooves in end zones of said rotor core such that the ventil-

ating medium will travel through said grooves and through said sub-slots and in the end zones from said grooves through some of said areas and through some of said tangential and axial passages to the periphery of said rotor and in the centre zone through some of said tangential and axial passages to other of said areas and into the adjacent grooves, thereby permitting said ventilating medium to enter said grooves adjacent the conductor bar material from high pressure areas and to leave said grooves through controlled and selected exit areas to ensure efficient use of the cooling properties of the ventilating medium.

10. A dynamo electric machine as claimed in Claim 1 having the stator formed with longitudinal grooves in the conductor sides and discharge passages through the core teeth substantially as described.

11. A dynamo electric machine having the rotor arranged substantially as herein described with reference to the accompanying drawing.

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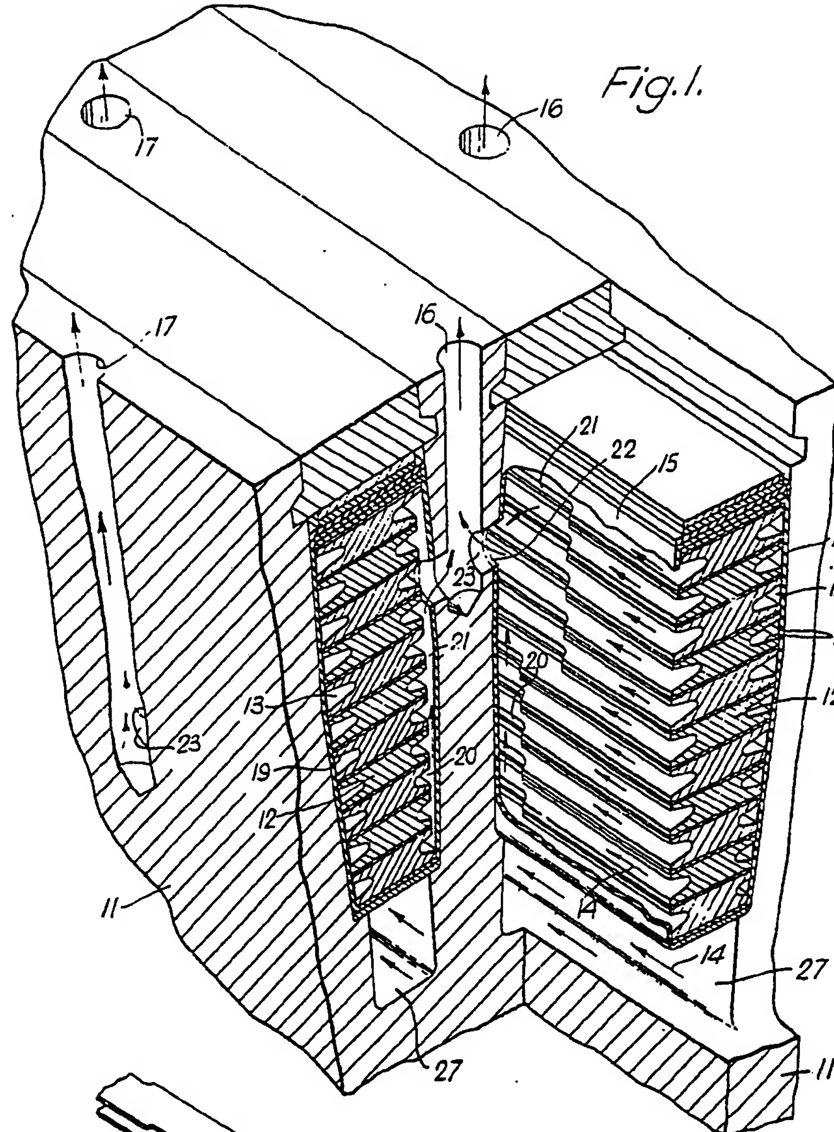
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Fig. 1.

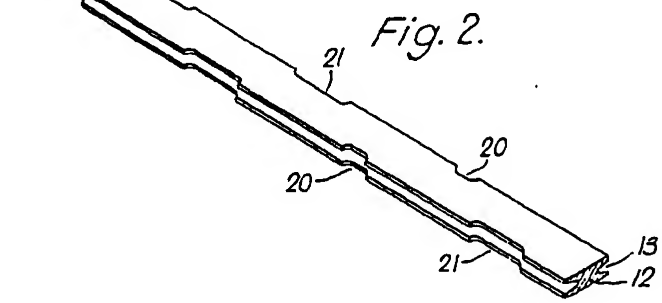
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Fig. 2.

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SHEETS 1 & 2

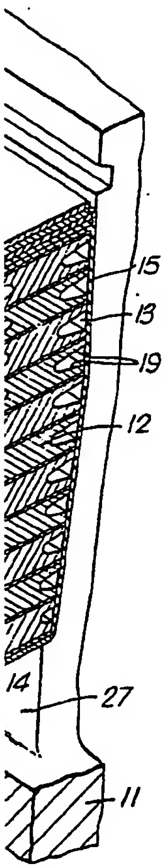
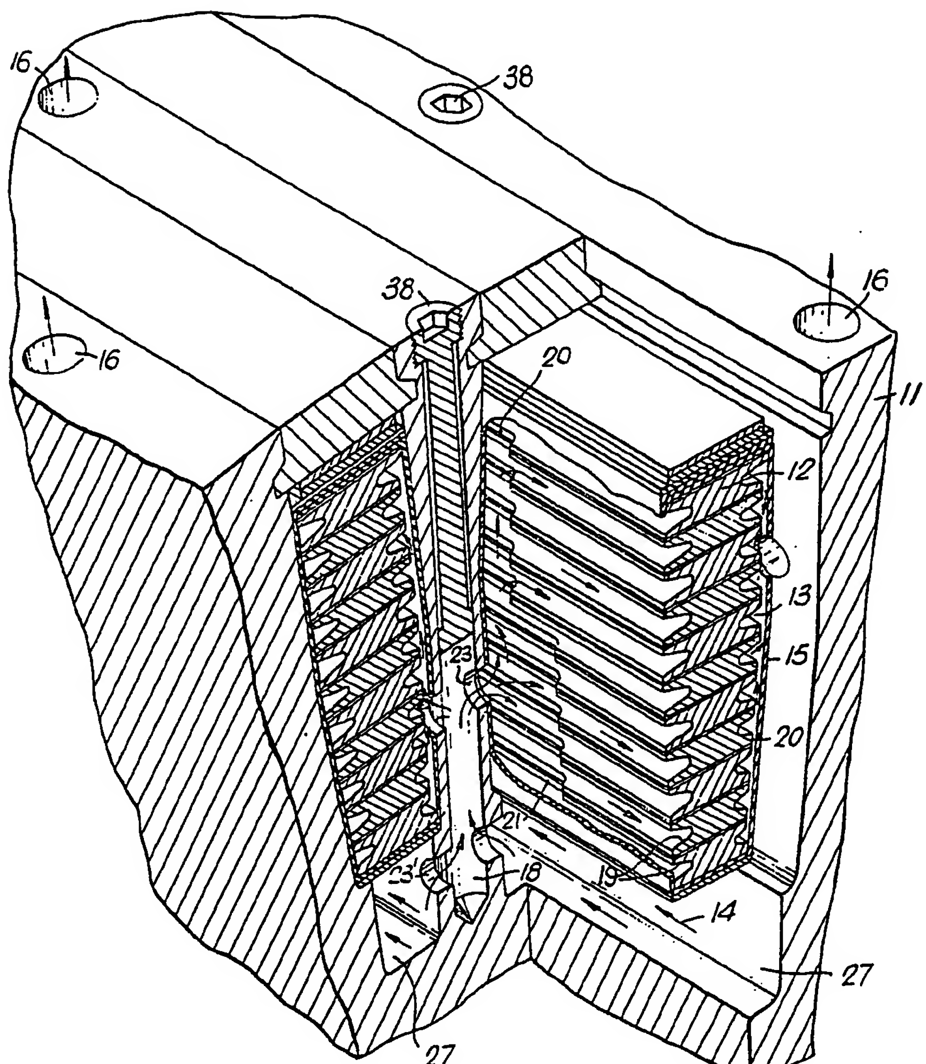


Fig. 5.



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SHEETS 1 & 2

Fig. 1.

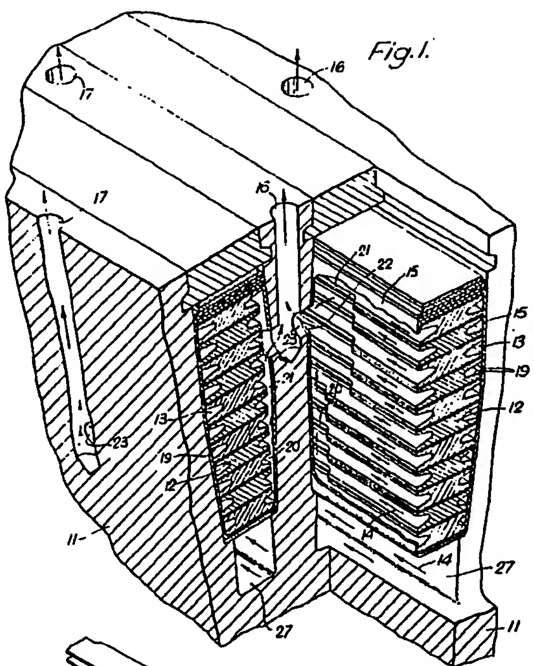


Fig. 2.

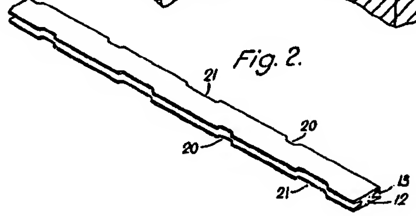
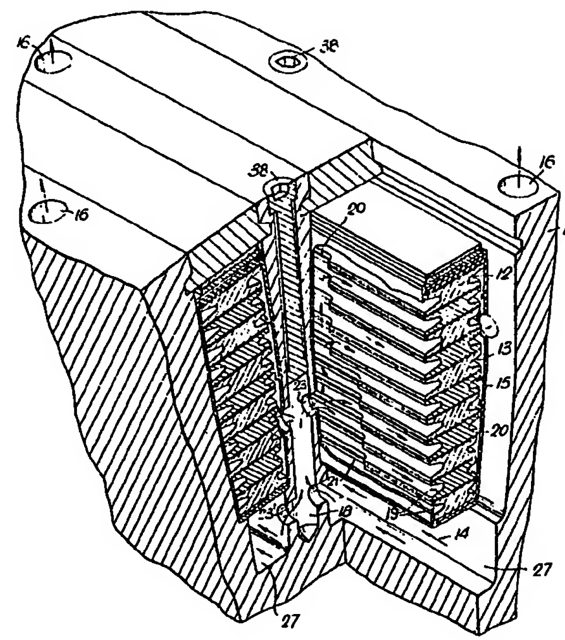


Fig. 5.



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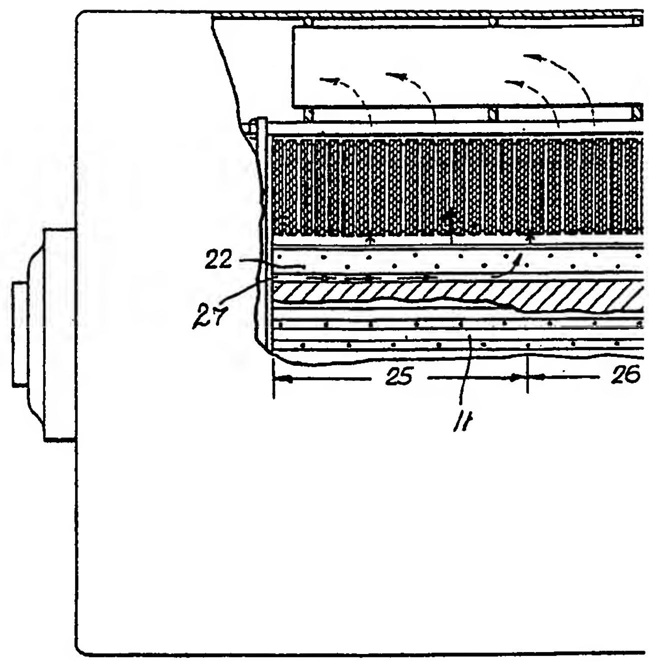

Fig.4.

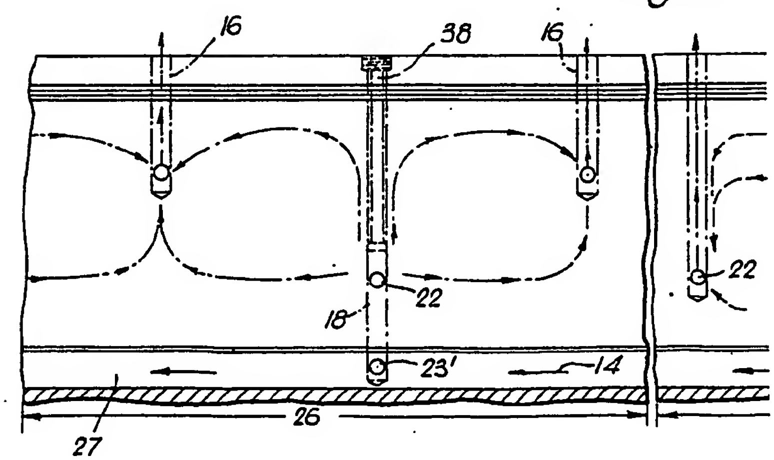

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Fig. 3.

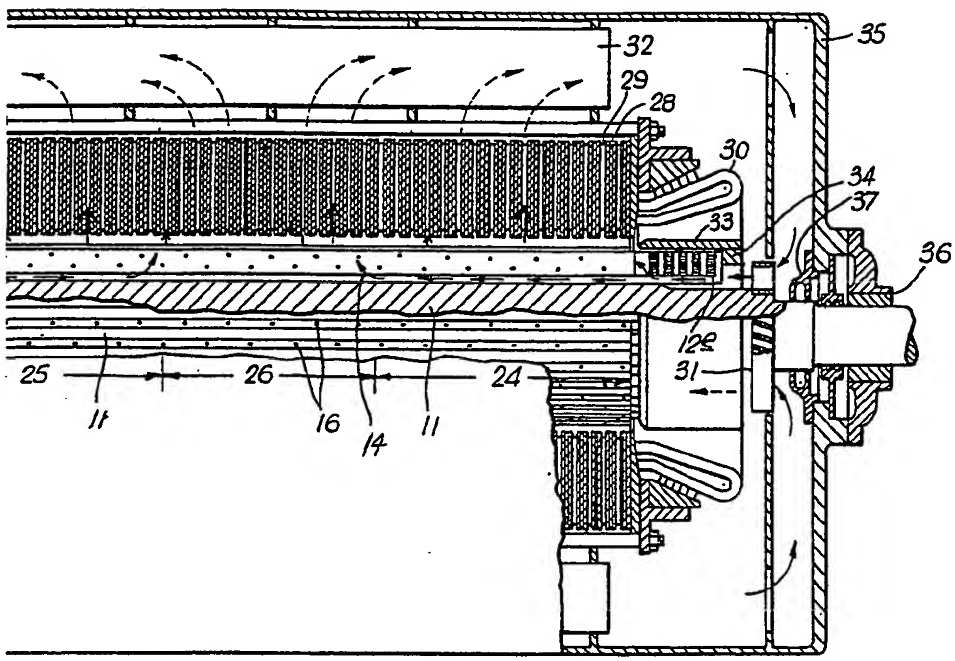

Fig. 4.

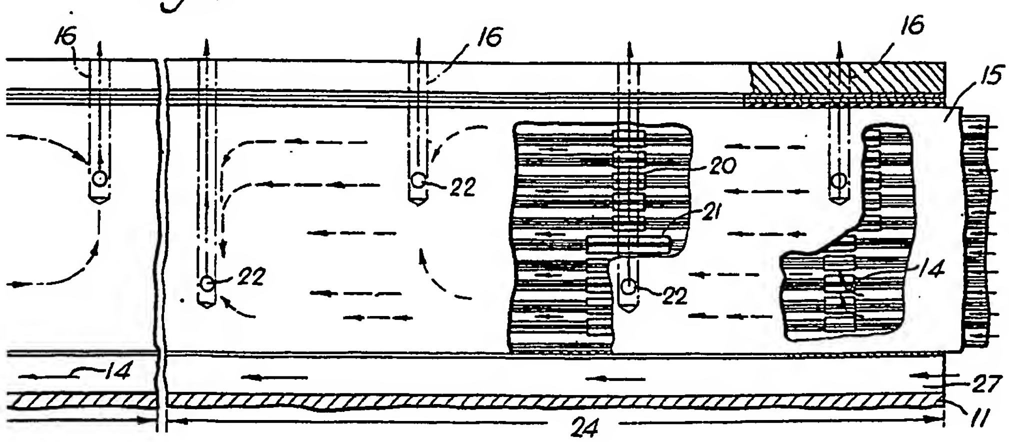

Fig. 3.

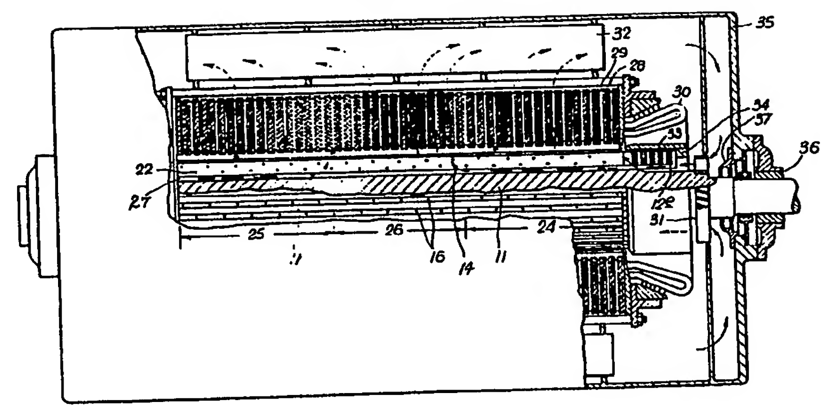
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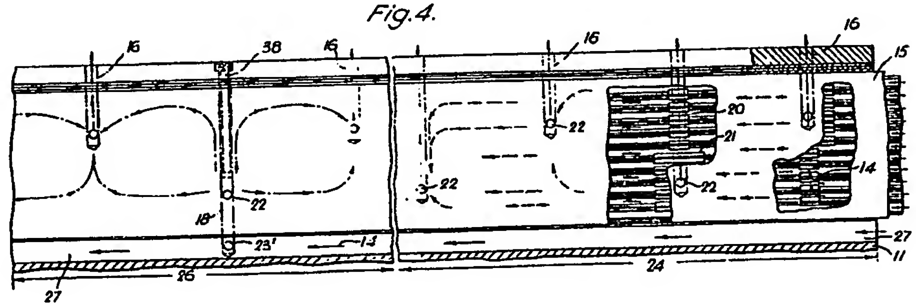
Fig. 4.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